Particle Flow Isolation for a SUSY analysis

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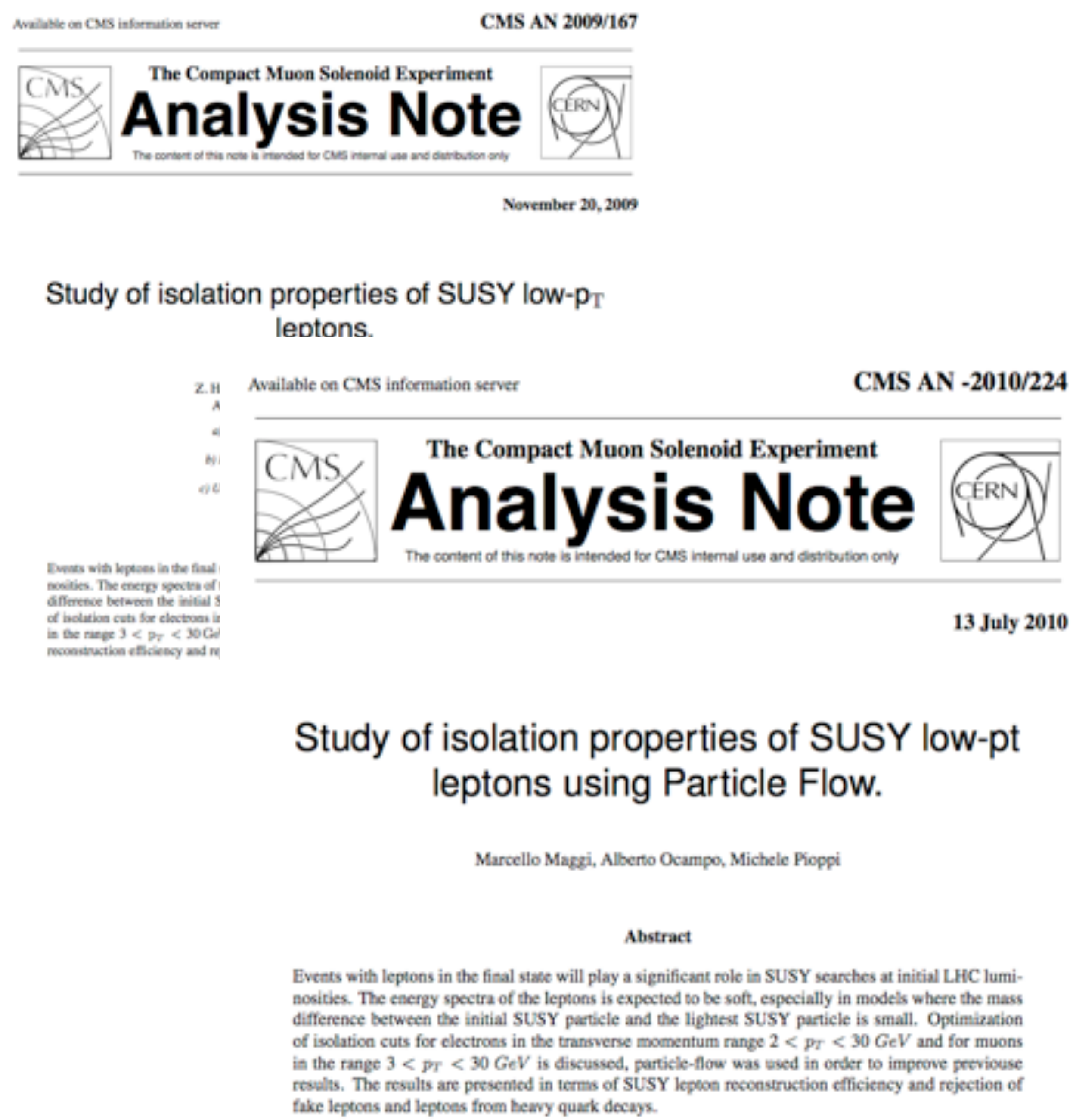
Outline

- Motivation
- Technical Details
- Optimisation
- Isolation used
- Event selection
- Efficiency vs rejection-plots
- Optimisation approaches
- SUSY results
- Data driven method
- Conclusions

Motivation

- We wanted to see the impact of Particle Flow in a leptonic SUSY search
- We wanted to compare the performance of Particle Flow PAT vs Standard RECO PAT
- In the case of degenerated masses for some SUSY particles (neutralinos for example) we expect a soft lepton spectrum, therefore we want to go as low as we can in pt
- There is a lepton isolation study done in the Standard RECO framework(CMS AN 2009-197), we reproduced it using Particle Flow (CMS AN 2010-224).



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Analysis Note

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November 20, 2009

Study of isolation properties of SUSY low-p_T leptons.

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13 July 2010

Study of isolation properties of SUSY low-pt leptons using Particle Flow.

Marcello Maggi, Alberto Ocampo, Michele Pioppi

Abstract

Events with leptons in the final state will play a significant role in SUSY searches at initial LHC luminosities. The energy spectra of the leptons is expected to be soft, especially in models where the mass difference between the initial SUSY particle and the lightest SUSY particle is small. Optimization of isolation cuts for electrons in the transverse momentum range $2 < p_T < 30\ GeV$ and for muons in the range $3 < p_T < 30\ GeV$ is discussed, particle-flow was used in order to improve previouse results. The results are presented in terms of SUSY lepton reconstruction efficiency and rejection of fake leptons and leptons from heavy quark decays.

Technical Details

PAT production

- CMSSW_3_6_2
- PAT Layer1 V6 recipe as appears at https://twiki.cern.ch/twiki/bin/view/CMS/SusyPatLayer1DefV8

Samples Used

- /LM0/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
- /LM1/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
- /InclusiveBB_Pt30/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
- /QCD_Pt250to500-madgraph/Summer09-MC_31X_V3_7TeV_preproduction-v1/GEN-SIM-RECO
- /QCD_Pt500to1000-madgraph/Summer09-MC_31X_V3_7TeV_preproduction-v1/GEN-SIM-RECO
- /QCD_Pt1000toInf-madgraph/Summer09-MC_31X_V3_7TeV_preproduction-v2/GEN-SIM-RECO
- /TTbarJets-madgraph/Summer09-MC_31X_V3_7TeV-v2/GEN-SIM-RECO
- /WJets-madgraph/Summer09-MC_31X_V3_7TeV_preproduction-v1/GEN-SIM-RECO

Jets Cleaned

A cleaning was applied for the Standard RECO Jets to clean jets from electrons.

RERECO

All the used samples were re-reco-ded so that the latest PF updates were included (thanks to michal bluj for the cfg), The used recipe is at https://twiki.cern.ch/twiki/bin/viewauth/CMS/PFlowDevelopers#3_6_0

3_6_X (slc5)

3_6_0

- Integration recipe by D. Benedetti, May 5, 12:10 Brem conversion recovery and usage of the egamma supercluster

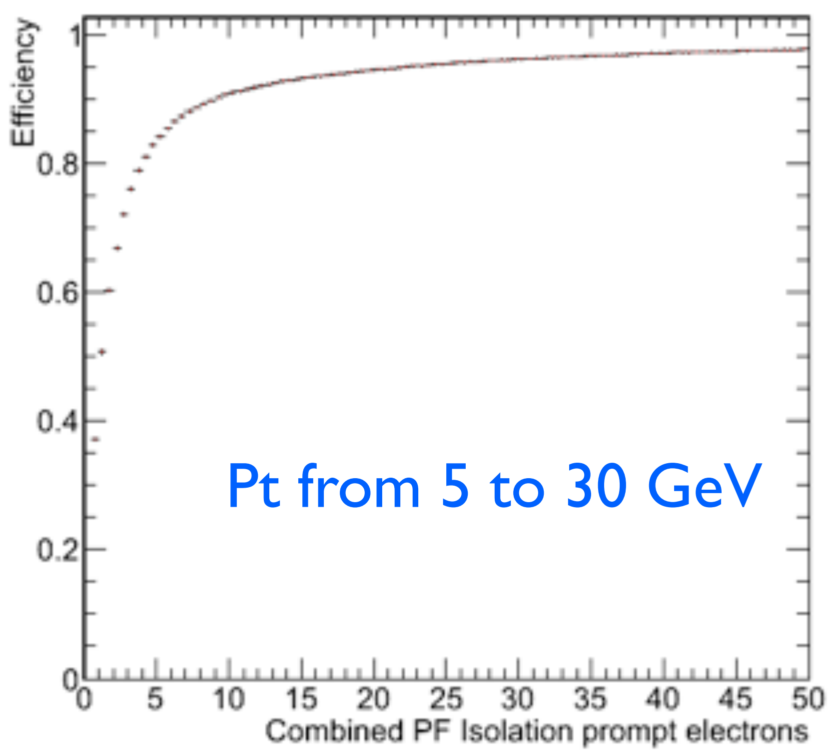
```
scram project CMSSW CMSSW_3_6_0
cd CMSSW_3_6_0/src
cmsenv
cat > pack <<END
DataFormats/ParticleFlowReco              Maxime-30Mar2010
RecoParticleFlow/PFTracking               ConvBremReco_DB_19Apr
RecoParticleFlow/PFRootEvent              ImportSCEG_DB_05May
RecoParticleFlow/PFProducer               ImportSCEG_DB_05May
RecoParticleFlow/PFClusterTools           SCDiverg_DB_07Apr10

END
addpkg -f pack
cd RecoParticleFlow/PFTracking/data
wget http://cmsdoc.cern.ch/cms/data/CMSSW/RecoParticleFlow/PFTracking/data/MVAnalysis_BDT.weights_convBremFinder_19Apr.txt
cd -
checkdeps -a
rm -rf AnalysisDataFormats *Analysis* Fireworks ISpy VisReco Validation DQMOffline/Trigger DQMOffline/JetMET
scram b -j 4
```

Optimisation

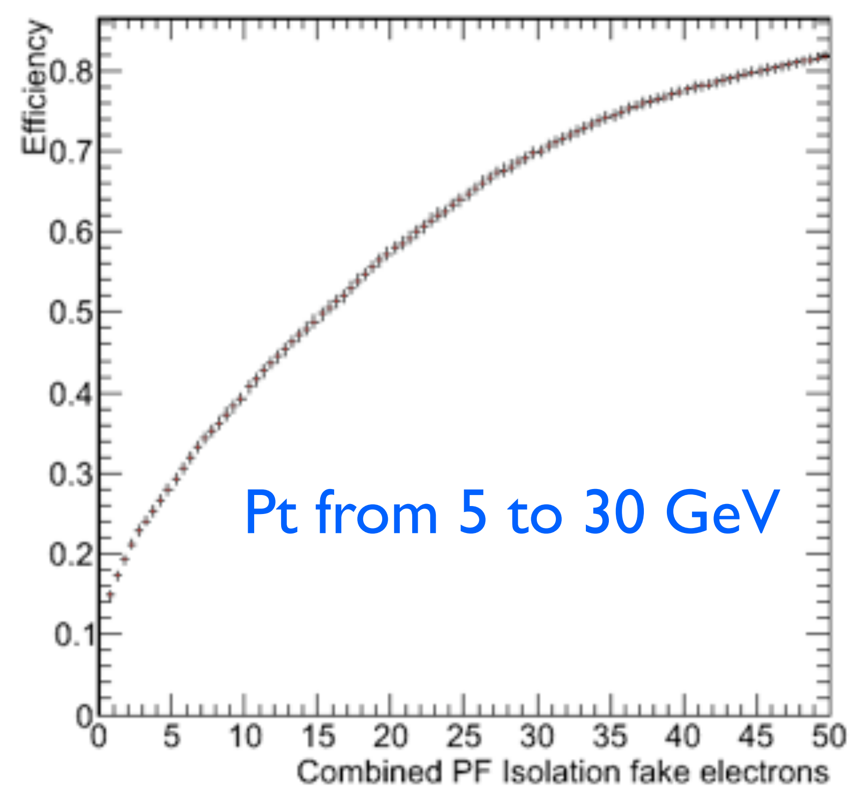
- We divided the leptons by their Pt in ranges of 3 GeV from 0 to 30 GeV.
- For each of these ranges we calculated the efficiency of detection as a function of isolation, we considered four possible cases:
  - Particle Flow:
    - Gamma Isolation, Charged Hadron Isolation, Neutral Hadron Isolation, and combined isolation.
  - Standard RECO:
    - Track Isolation, ECAL Isolation, HCAL Isolation, and combined isolation.

$$Eff = \frac{\text{Number of leptons}(Iso, P_T)}{\text{Total number of leptons}(P_T)}$$

$$rej(Iso) = 1 - Eff(Iso)$$



VS



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Isolation Calculation

PAT leptons were produced using this isolations

Standard RECO

$$Iso_{abs}^{track} = \sum_{\Delta R<0.3} P_T^{track}$$

$$\downarrow$$

$$Iso_{abs}^{ECAL} = \sum_{\Delta R<x} E_T^{ECAL} \rightarrow \begin{cases} x = 0.3 & \text{if } \mu \\ x = 0.4 & \text{if } e \end{cases}$$

$$\downarrow$$

$$Iso_{abs}^{HCAL} = \sum_{\Delta R<x} E_T^{HCAL} \rightarrow \begin{cases} x = 0.3 & \text{if } \mu \\ x = 0.4 & \text{if } e \end{cases}$$

$$\downarrow$$

$$Iso_{abs}^{comb} = \sum_{\Delta R<0.3} P_T^{track} + \sum_{\Delta R<x} E_T^{HCAL} \rightarrow \begin{cases} x = 0.3 & \text{if } \mu \\ x = 0.4 & \text{if } e \end{cases}$$

Particle Flow

$$PFIso_{abs}^{ChargedHadrons} = \sum_{\Delta R<0.4} P_T^{PFChargedHadrons}$$

$$\downarrow$$

$$PFIso_{abs}^{NeutralHadrons} = \sum_{\Delta R<0.4} P_T^{PFNeutralHadrons}$$

$$\downarrow$$

$$PFIso_{abs}^{Gamma} = \sum_{\Delta R<0.4} P_T^{PFPhotons}$$

$$\downarrow$$

$$PFIso_{abs}^{comb} = \sum_{\Delta R<0.4} P_T^{PFPhotons} + \sum_{\Delta R<0.4} P_T^{PFChargedHadrons} + 0.333 \sum_{\Delta R<0.4} P_T^{NeutralHadrons}$$

Event requirements

SUSY has a very dense environment therefore we applied a cut in $H_T > 300$ GeV requiring Jets with Pt > 50 GeV.

Lepton classification based on MC

- "Prompt" leptons, originated by SUSY decay particles, a boson, W/Z or a Tau.
- "Heavy Flavor" leptons, coming from hadronic decays of heavy flavor particles (b/c).
- "Fake" leptons, did not have any corresponding lepton at the truth generated level.
- MC truth was done using a $\Delta R < 0.5$

$$\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$$

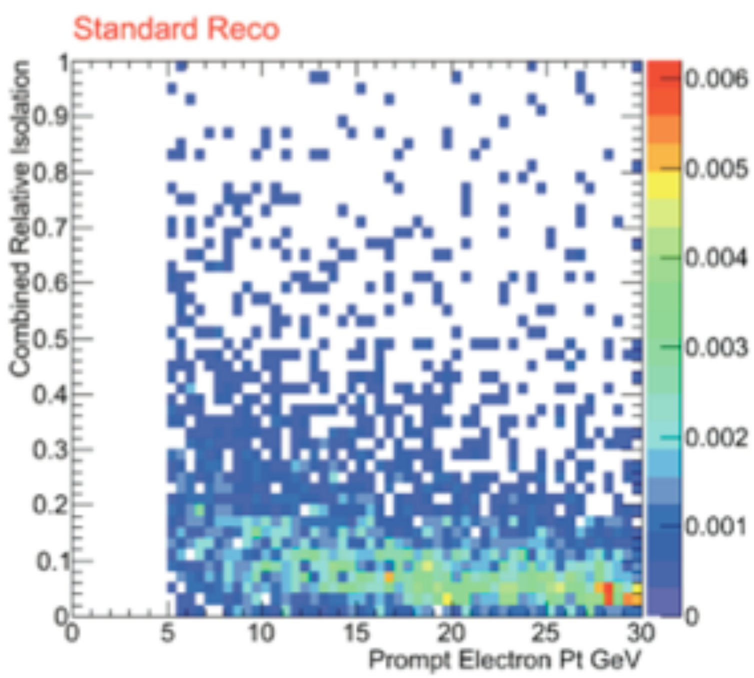
Electron Selection

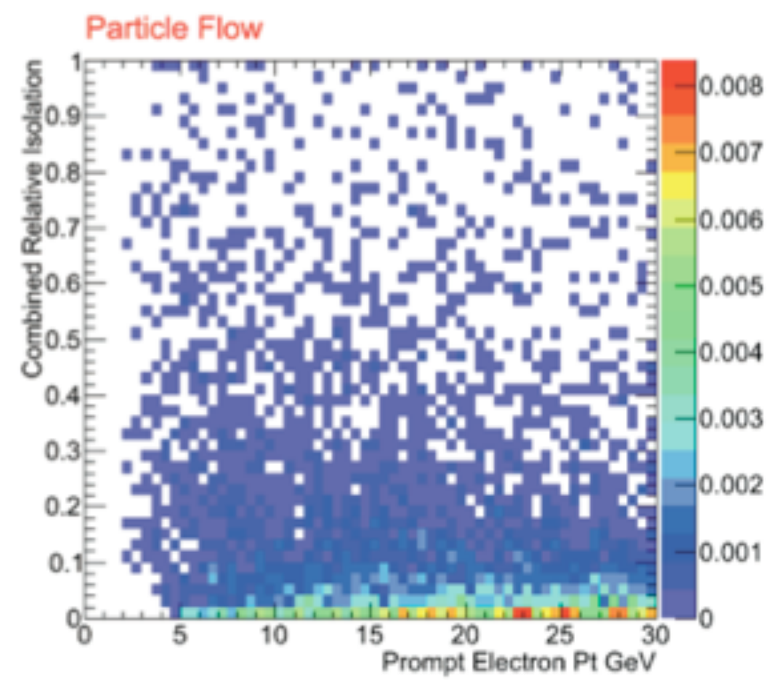
- Pt > 2 GeV
- $|\eta| < 2.5$
- mva > 0.6
- H over E < 0.06
- Transverse impact corrected for the beam spot < 2mm

Muon Selection

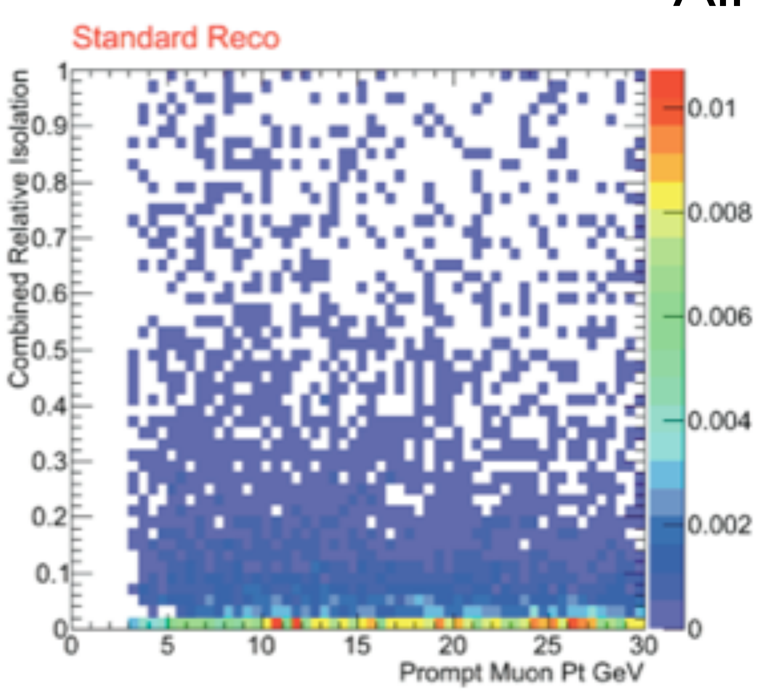
- Pt > 3 GeV
- $|\eta| < 2.1$
- Transverse impact corrected for the beam spot < 2mm
- Normalized global $\chi^2 < 10$
- Number of hits in the tracker track > 11

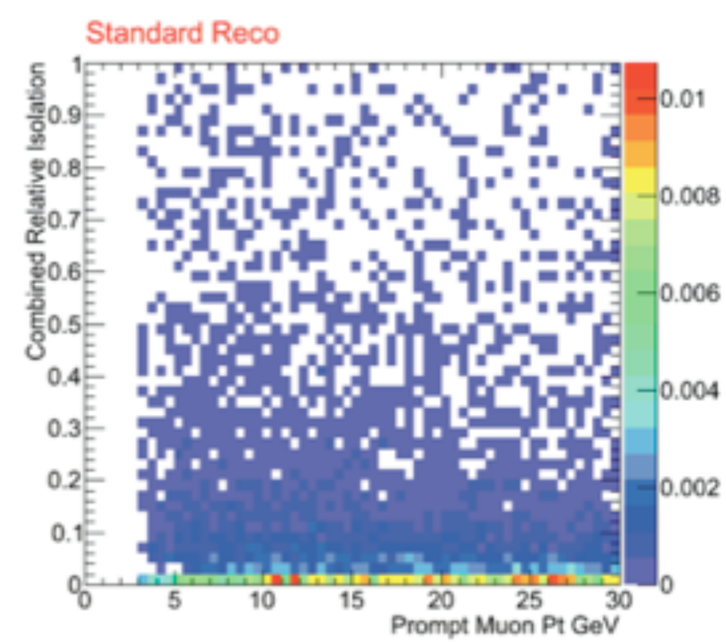
Combined Relative Isolation Prompt





All weights taken as 1





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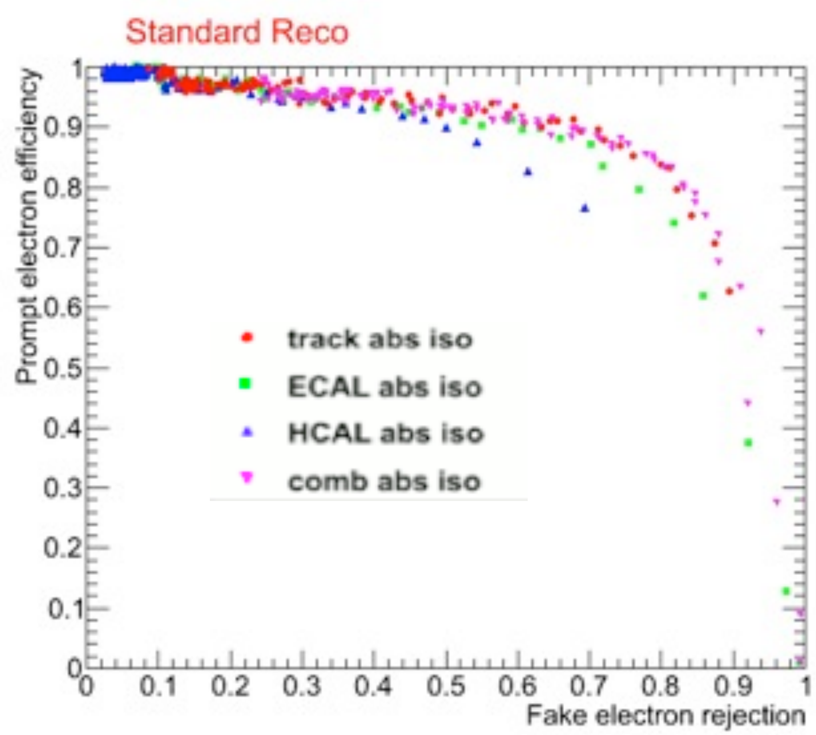
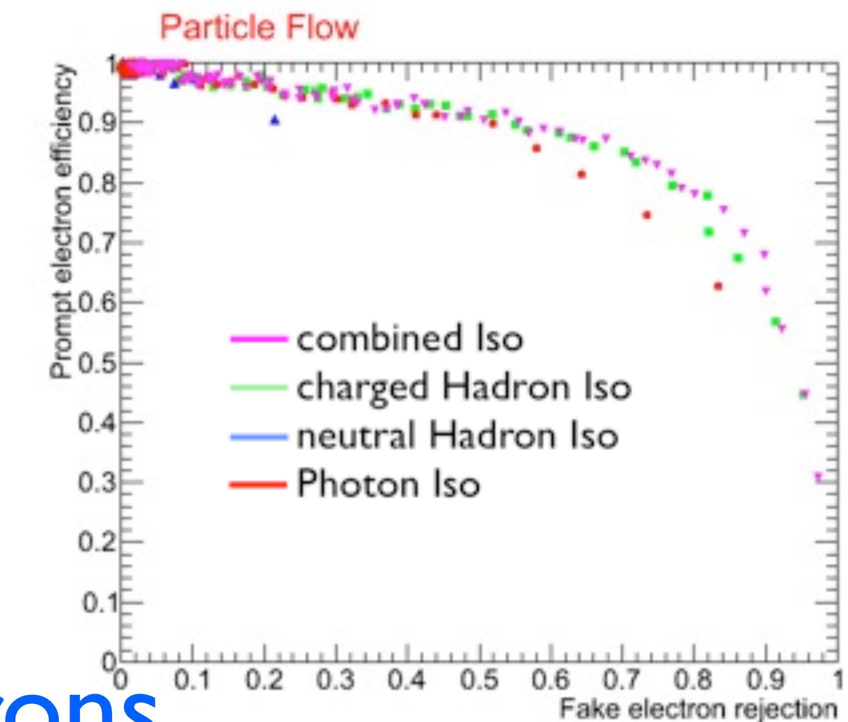
Efficiency vs Rejection

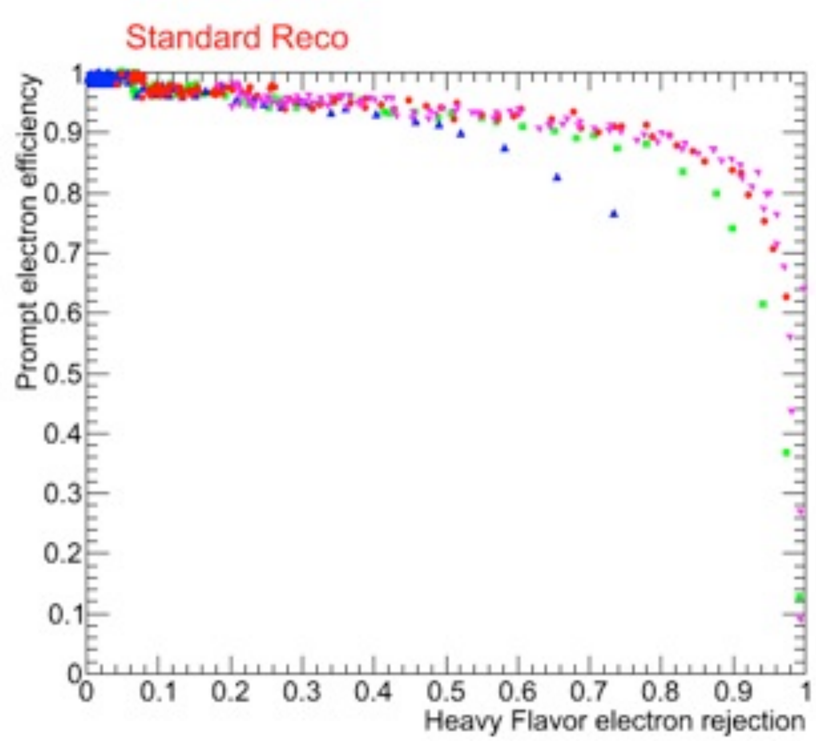
Pt from 5 to 30 GeV

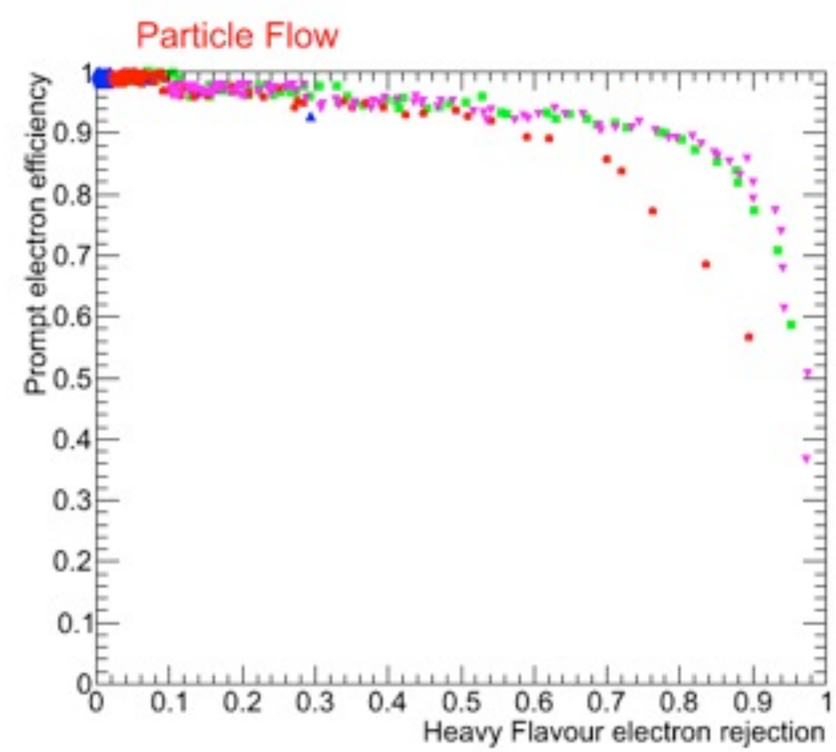


Pt from 2 to 30 GeV



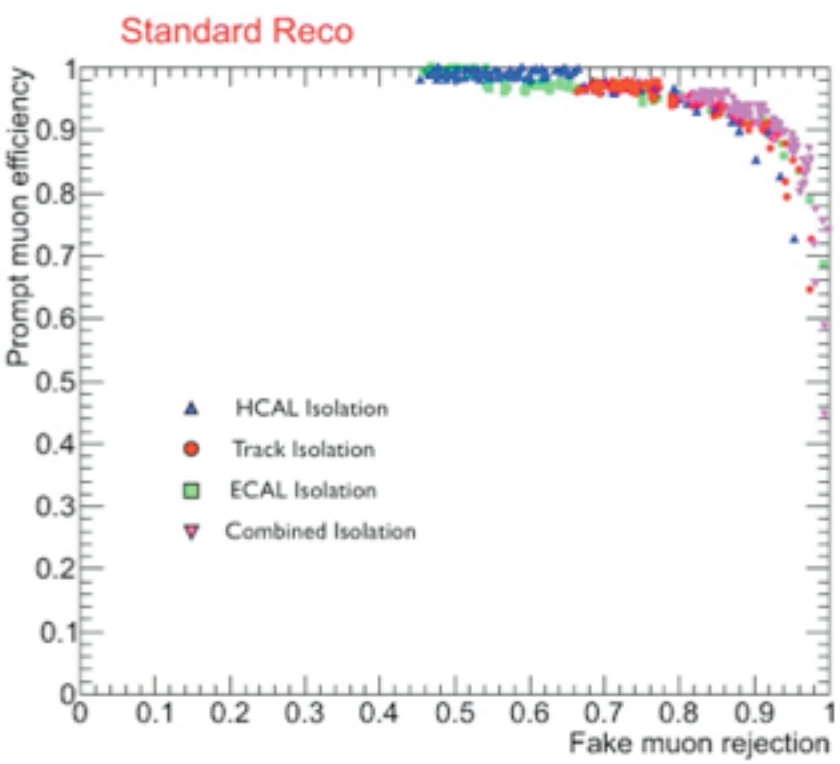
Electrons

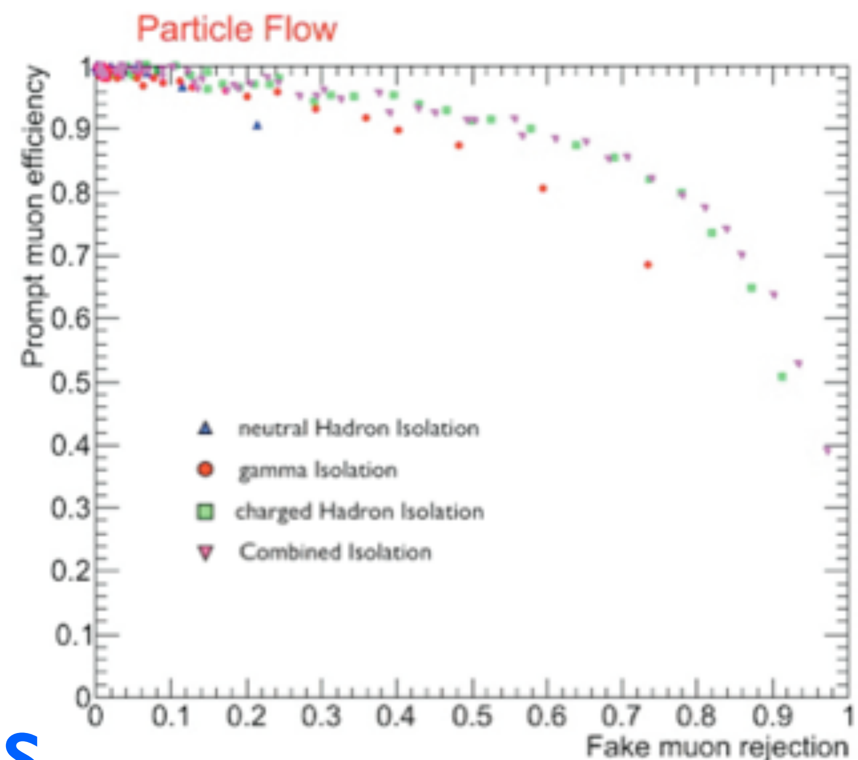




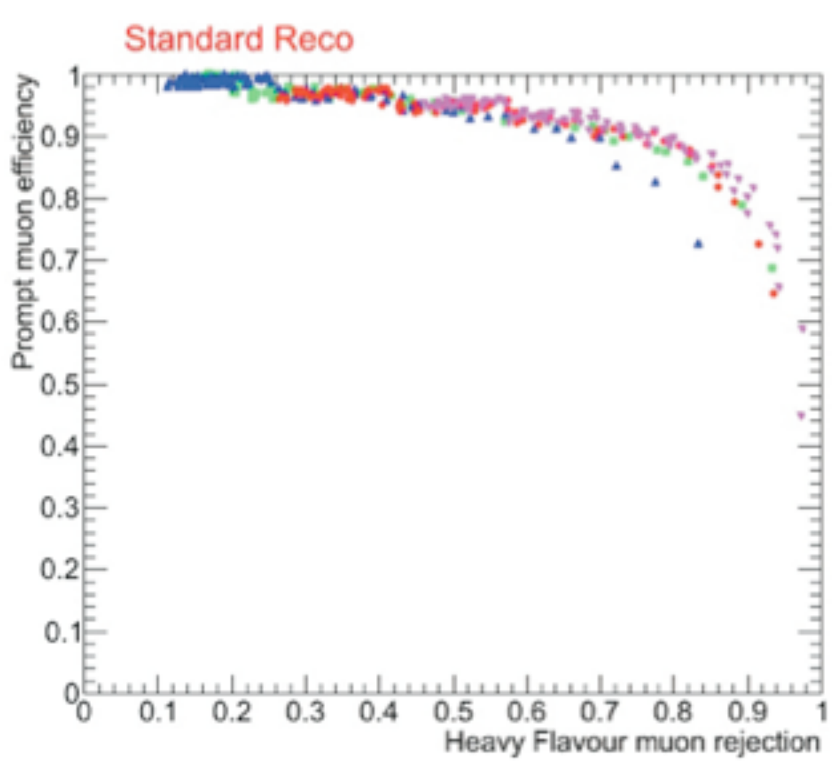
Efficiency vs Rejection

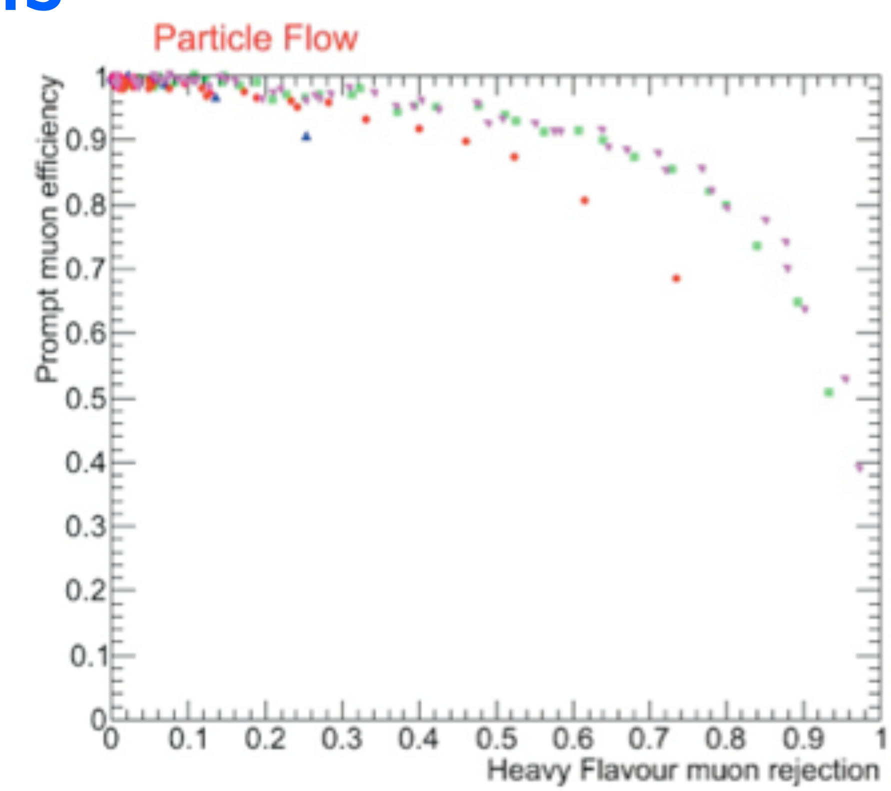
Pt from 3 to 30 GeV





Muons



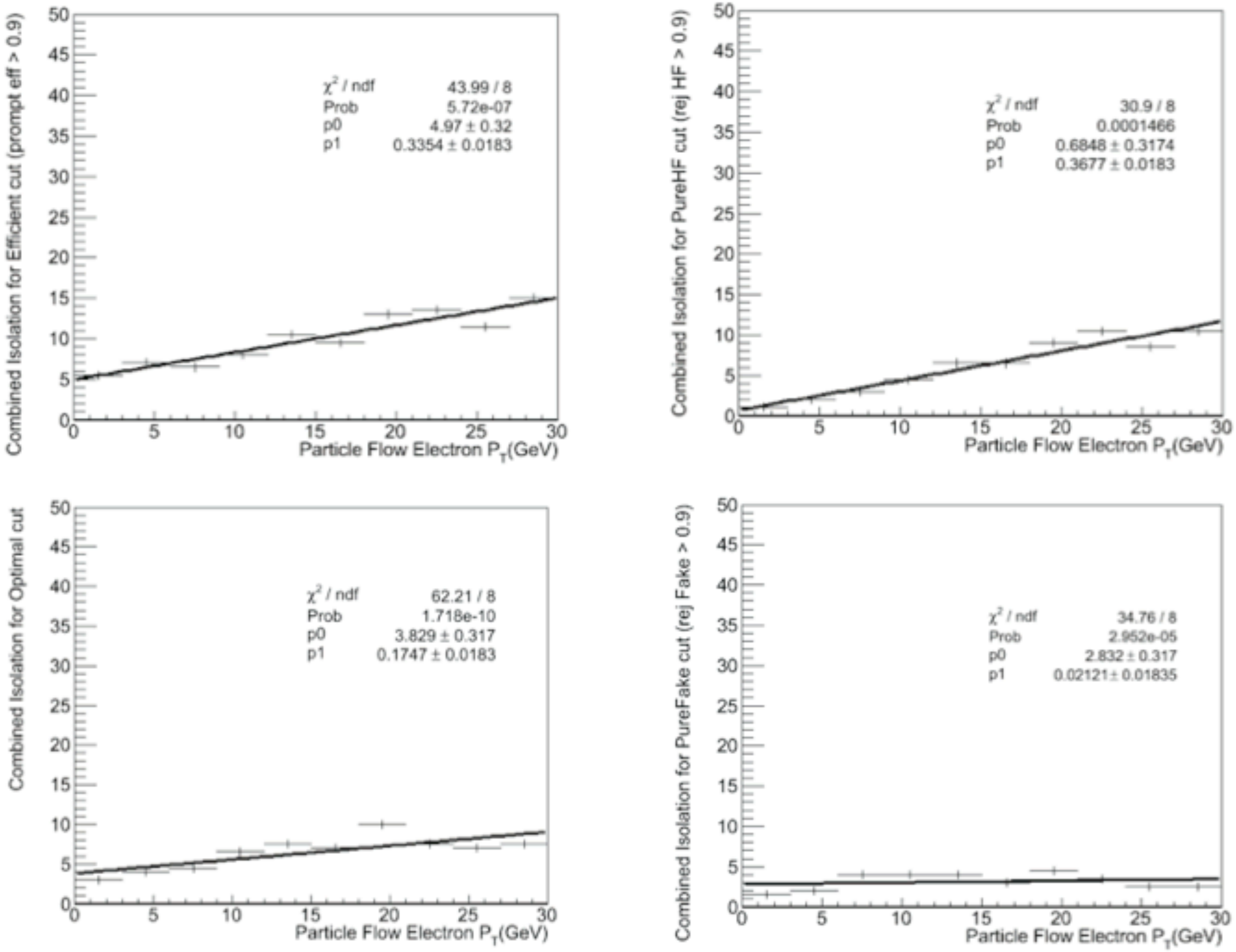


Five Optimisation Approaches

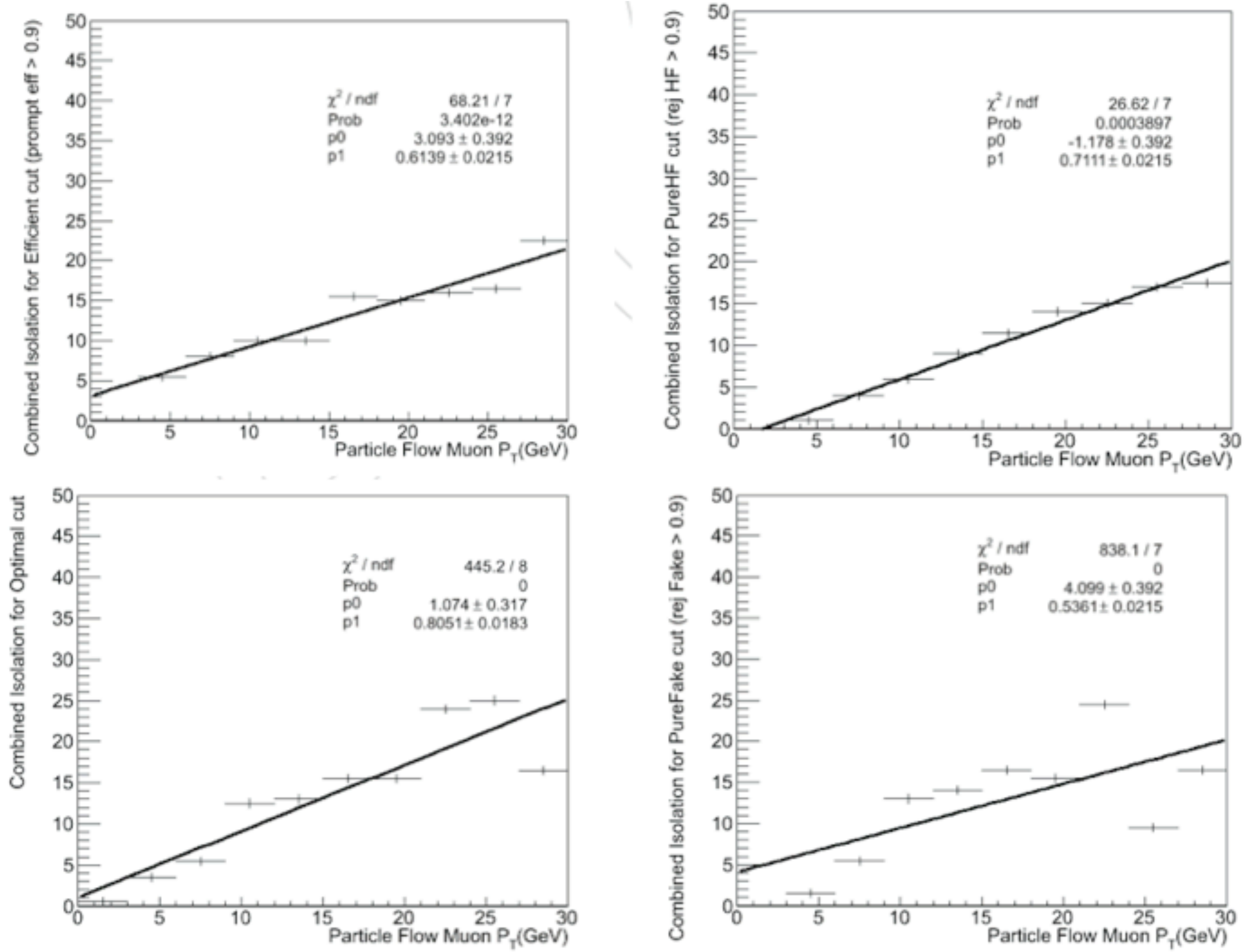
- We aim to have the same isolation performance for all the pt bins
- Several scenarios were considered
  - Leptons with pt bigger than:
    - 10 GeV
    - 5 GeV
    - 2 GeV
- For each point we required

- **PureHeavyFlavor**
  Highest cut on isolation at which $\mathrm{rej}_{\text{heavy-flavor}} \geq 0.9$
- **PureFake**
  Highest cut on isolation at which $\mathrm{rej}_{\text{fake}} \geq 0.9$
- **Optimal**
  Minimizes $x = \sqrt{(1-\mathrm{eff})^2 + (1-\mathrm{rej}_{\text{fake}})^2}$
- **Efficient**
  Lowest cut on isolation at which $\mathrm{eff}_{\text{prompt}} \geq 0.9$
- **V+ jets**
  Combined relative Isolation < 0.1 and pt > 10 GeV

Isolation cut vs Pt electrons



Isolation cut vs Pt muons

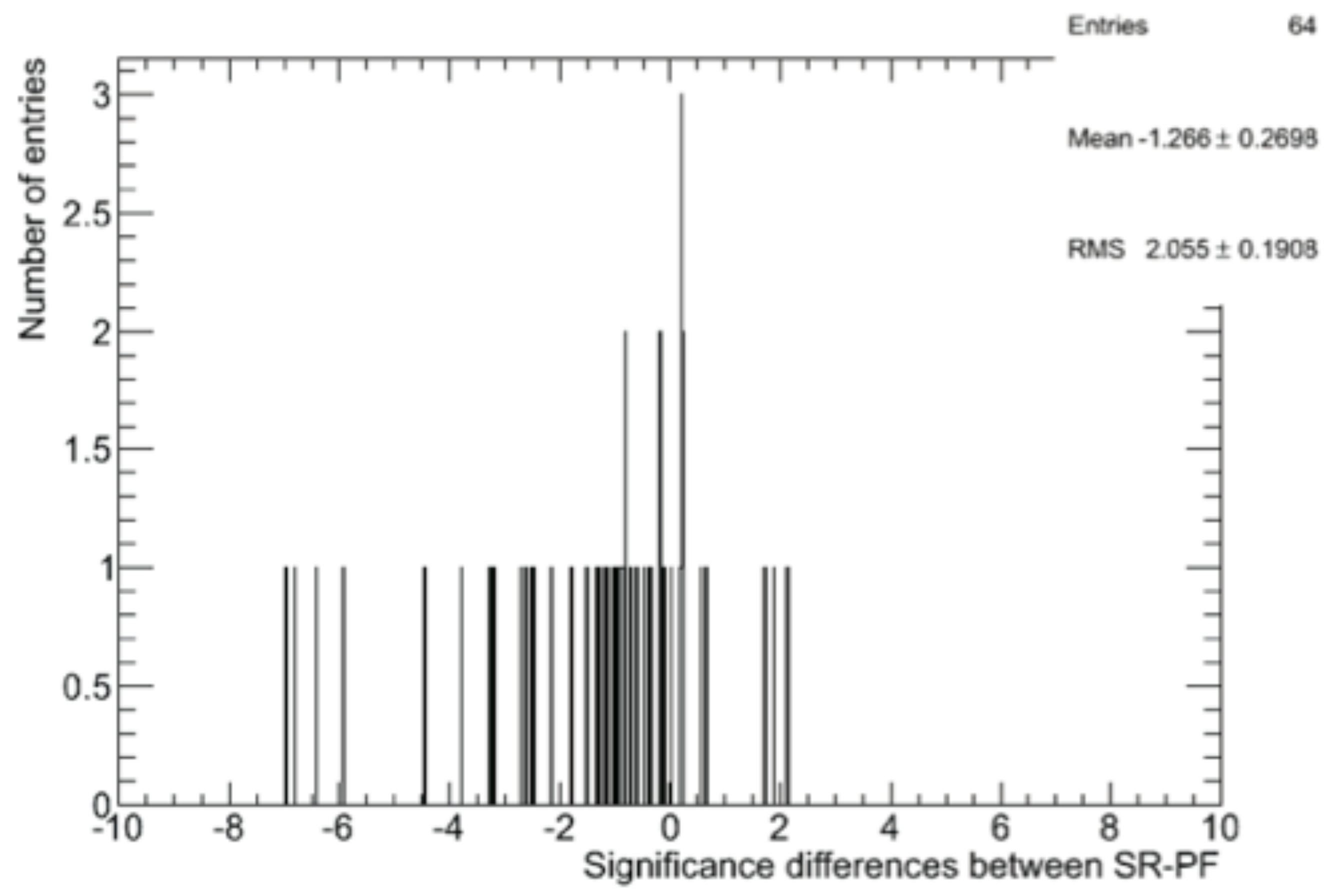


Applying to SUSY

- We applied the previous lepton selections in a few simple SUSY samples, in addition we required 3 jets with pt > 50 GeV and MET bigger than 50 or 100 GeV depending on the case (Single lepton, Double lepton).
- We worked with 64 SUSY cases which are:
  - 2 mSUGRA benchmarks, LM0 , LM1
  - 2 Single Lepton cases, electron, and muon.
  - 2 Double lepton cases, same sign and opposite sign double lepton with
    - ee, e-mu, mu-mu for each of them
  - 4 Isolation pt cuts
    - v+jets selections
    - optimal cut for different pt threshold
      - 10 GeV
      - 5Gev
      - 2Gev

Significance Differences between PF2PAT and PAT

- The significance was calculated for Single lepton selection, Same sign double lepton selection, and opposite sign double lepton selection. Taking the difference between the Standard Reco significance and the Particle Flow Significance, we have that in most of the cases PF performance is better.



Determining soft lepton isolation properties using JPsi's and b-tagged leptons

- We found a way to do the same using real data.
- We are using the jpsi reconstructed with muons (electrons) to select prompt leptons.
- We are using b-tagged to obtain Heavy flavour leptons.
- We are also simulating fakes using calomuons for muons and using electron anti-selection in mva for electrons.
- We are using only particle flow.
- We want to use a hadronic trigger (lepton pt is to low, SingleJet30) together with a HT cut.

Prompts

- For the electrons, conversions are rejected requiring 0 or 1 hit in the inner pixels.
- Two opposite sign leptons were required in both cases.
- The invariant mass of the pair should be in the interval (2 ,4) GeV.
- PF MVA > 0.3 was required for the first electron (higher pt) and MVA > -0.1 for the second one.
- The two leptons reconstruct a vertex with probability > 0.1.
- A cut in the vertex d0 < 0.2 to reject b-decay jpsis was required
- In the muon case, tracker muon and global muon were required .

Heavy Flavour

- The track Counting Higg Efficiency B-Jet tagged collection was used.
- The Btag discriminator > 10 was required, that is a very tight impact parameter.
- Only one lepton per jet, in the second hemisphere.

Fake muons

- Fake muons were obtained by matching PAT muons with calomuons

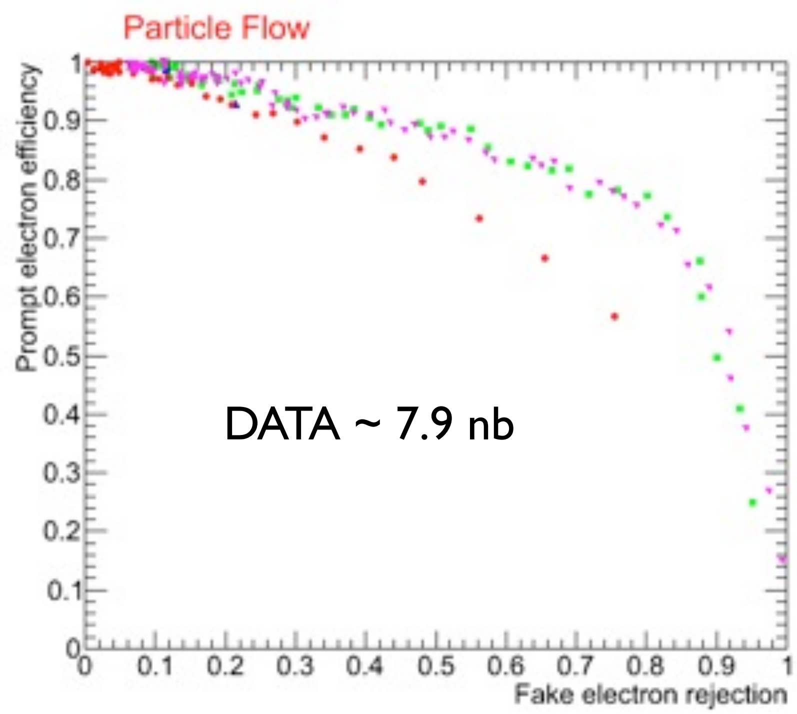
Fake electrons

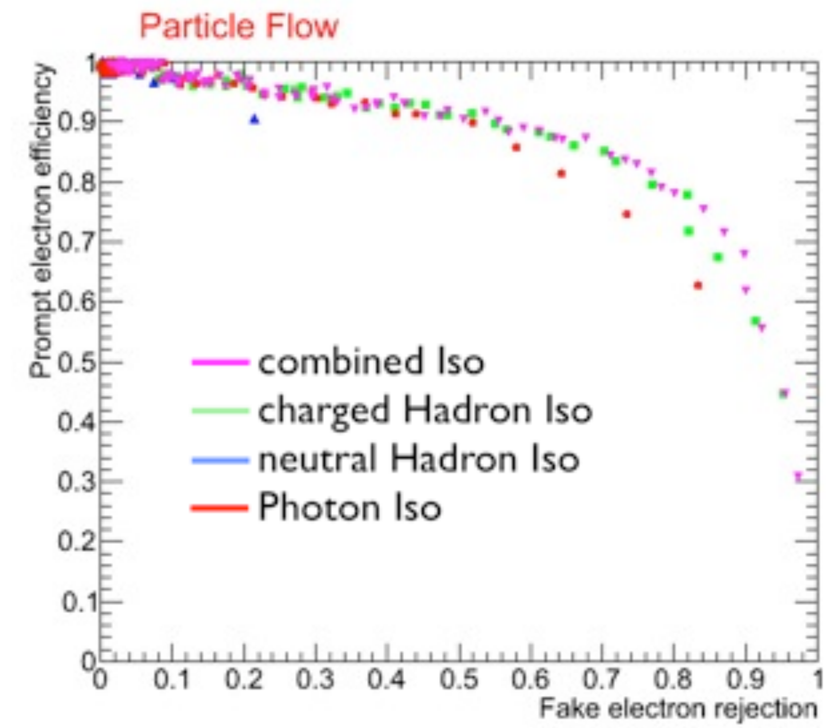
- Particle flow electron candidate with mva < -1 were matched with PAT electrons to identify fakes

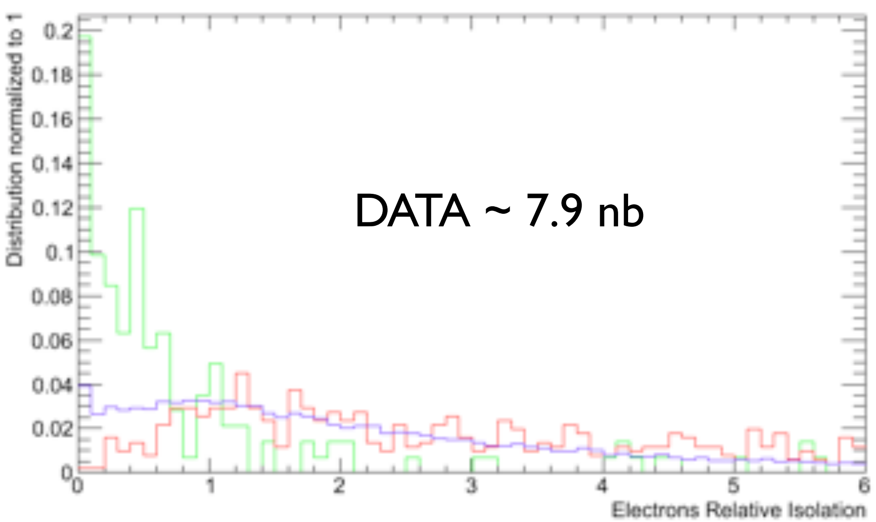
Efficiency vs Rejection

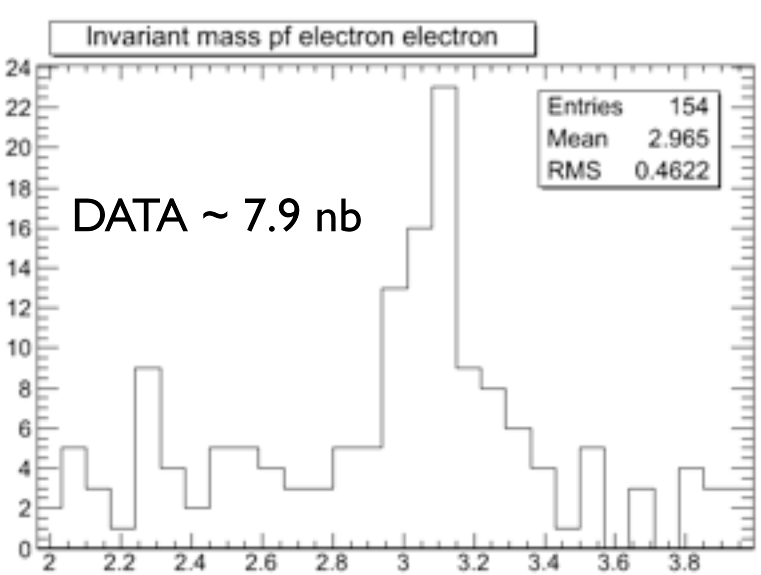
Data plots done with no HT cut, we want to redo this plots requiring a HT cut and a Single jet trigger.
We want to see this plot in a SUSY similar environment.

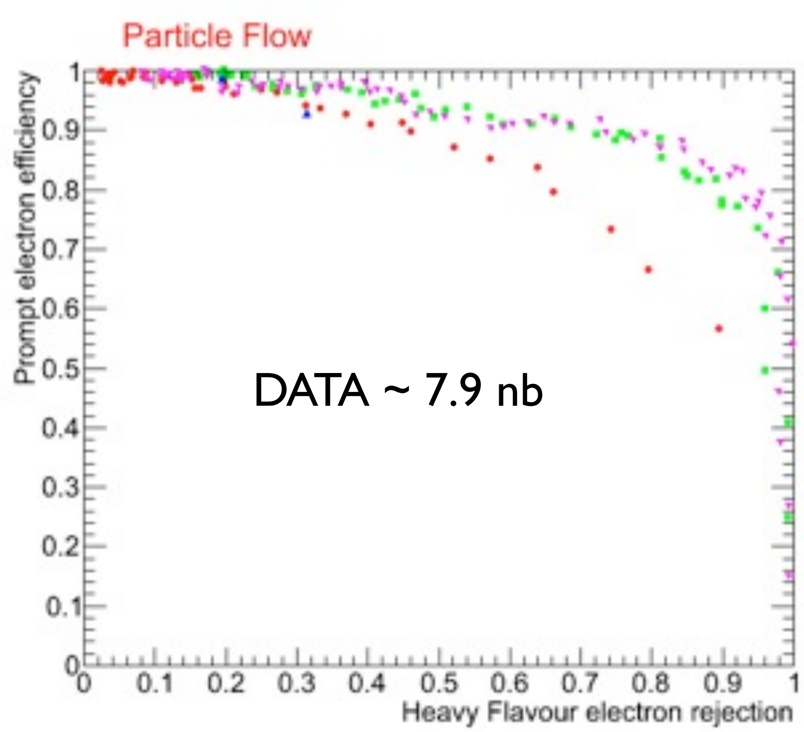
Electrons   Pt from 2 to 30 GeV

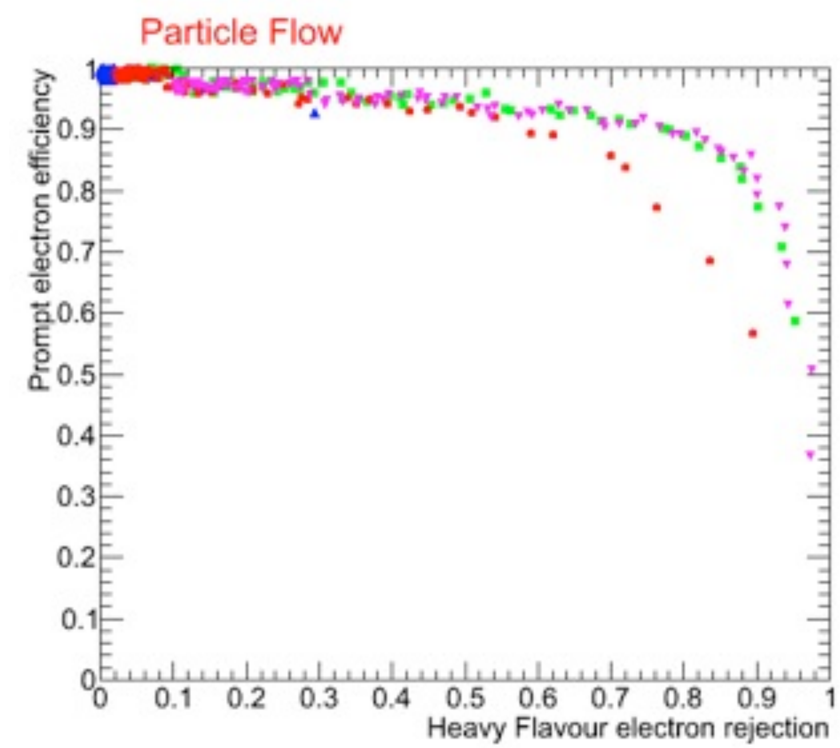












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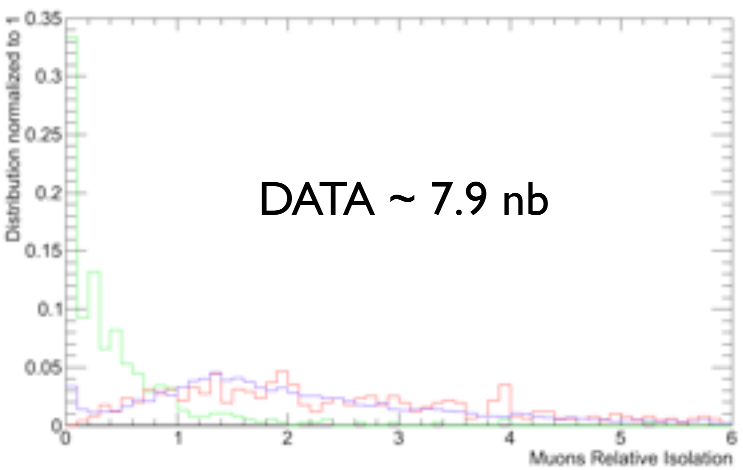
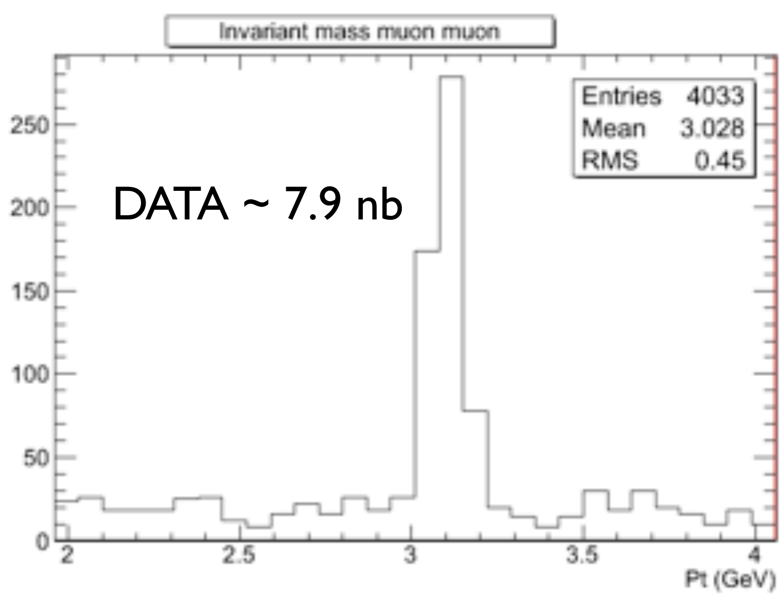
Efficiency vs Rejection

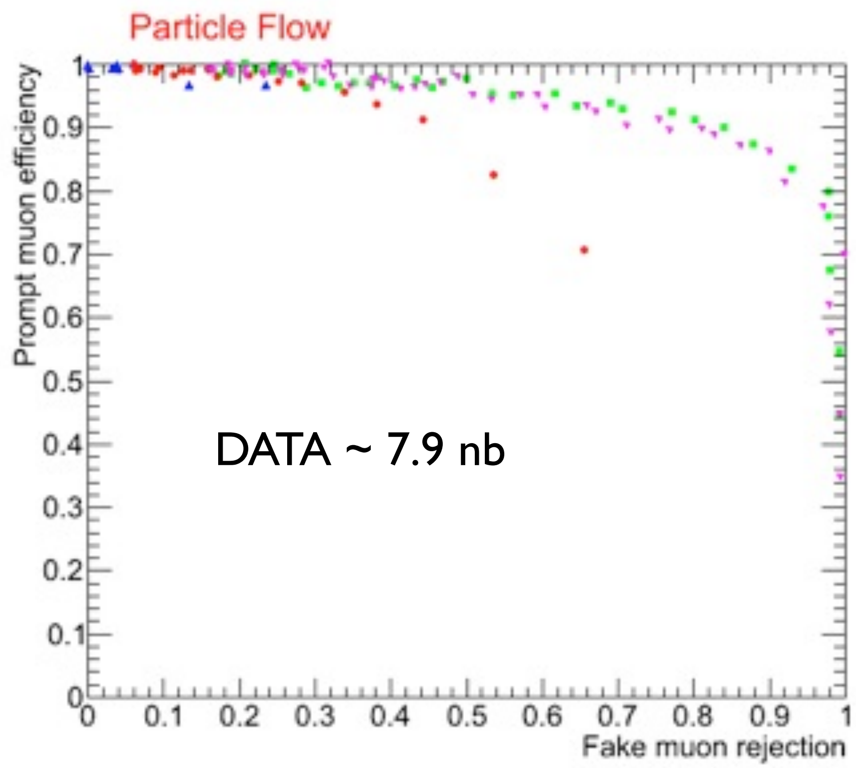
Data plots done with no HT cut, we want to redo this plots requiring a HT cut and a Single jet trigger.
We want to see this plot in a SUSY similar environment.

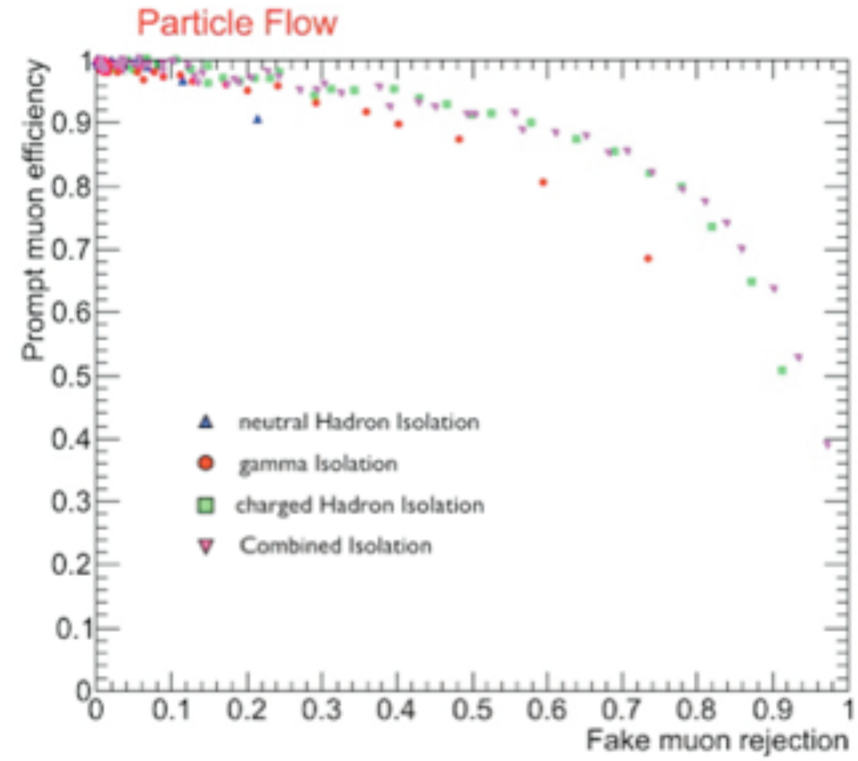


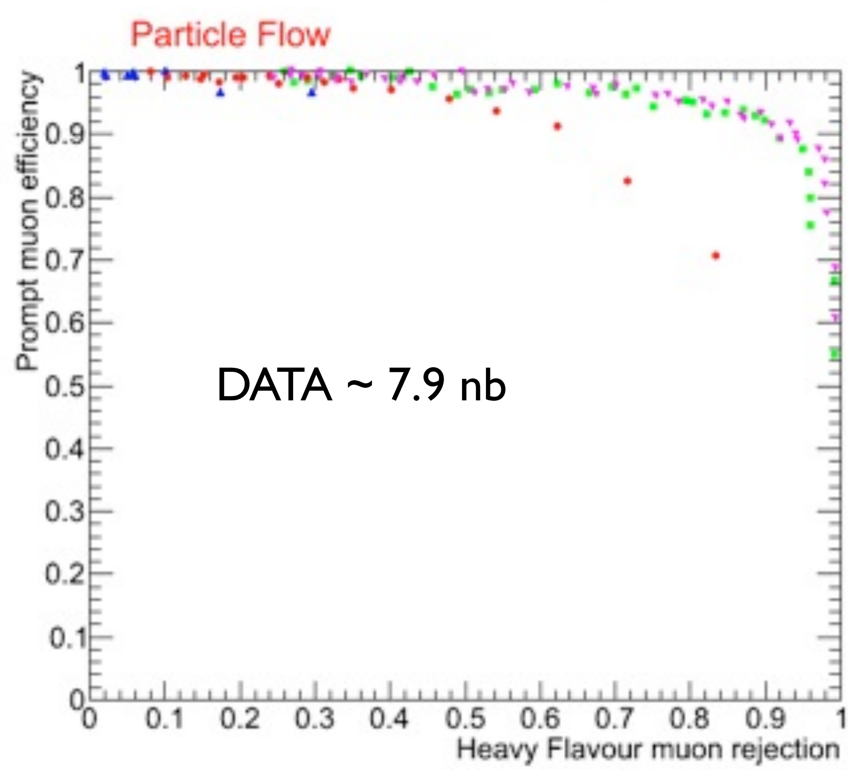


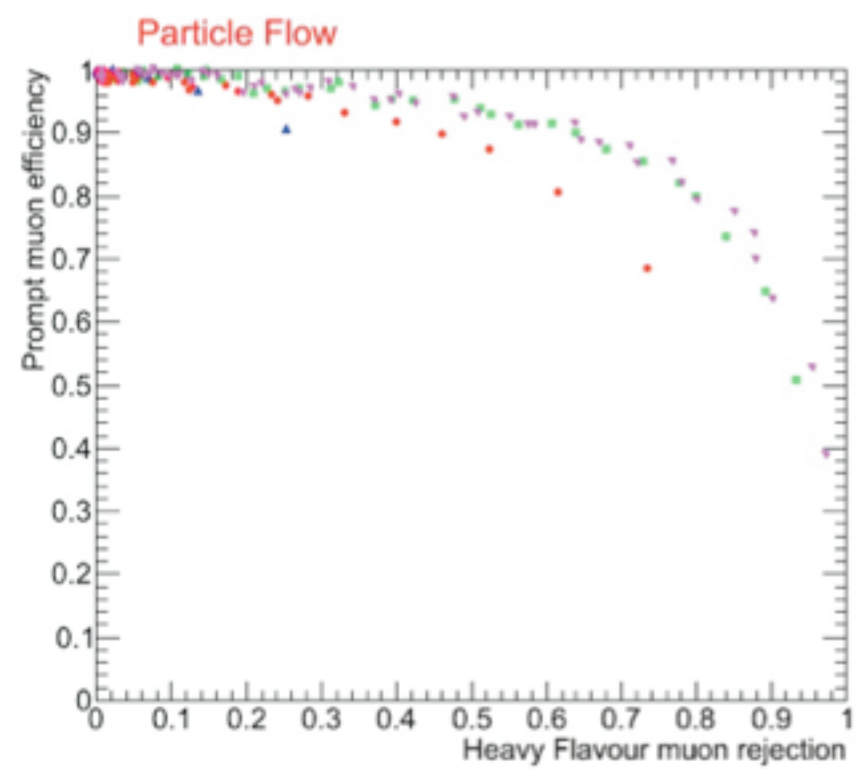
Muons

Pt from 3 to 30 GeV







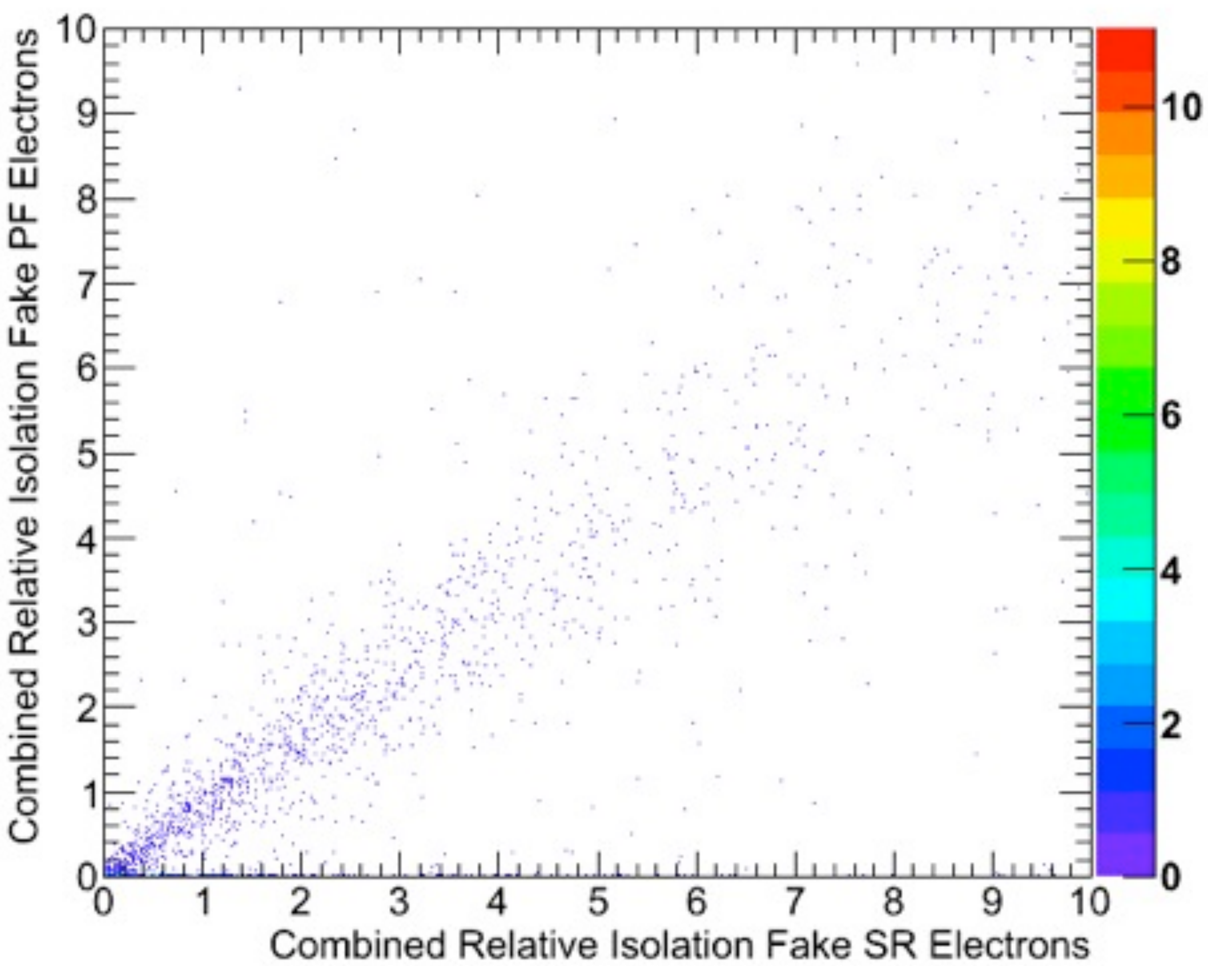


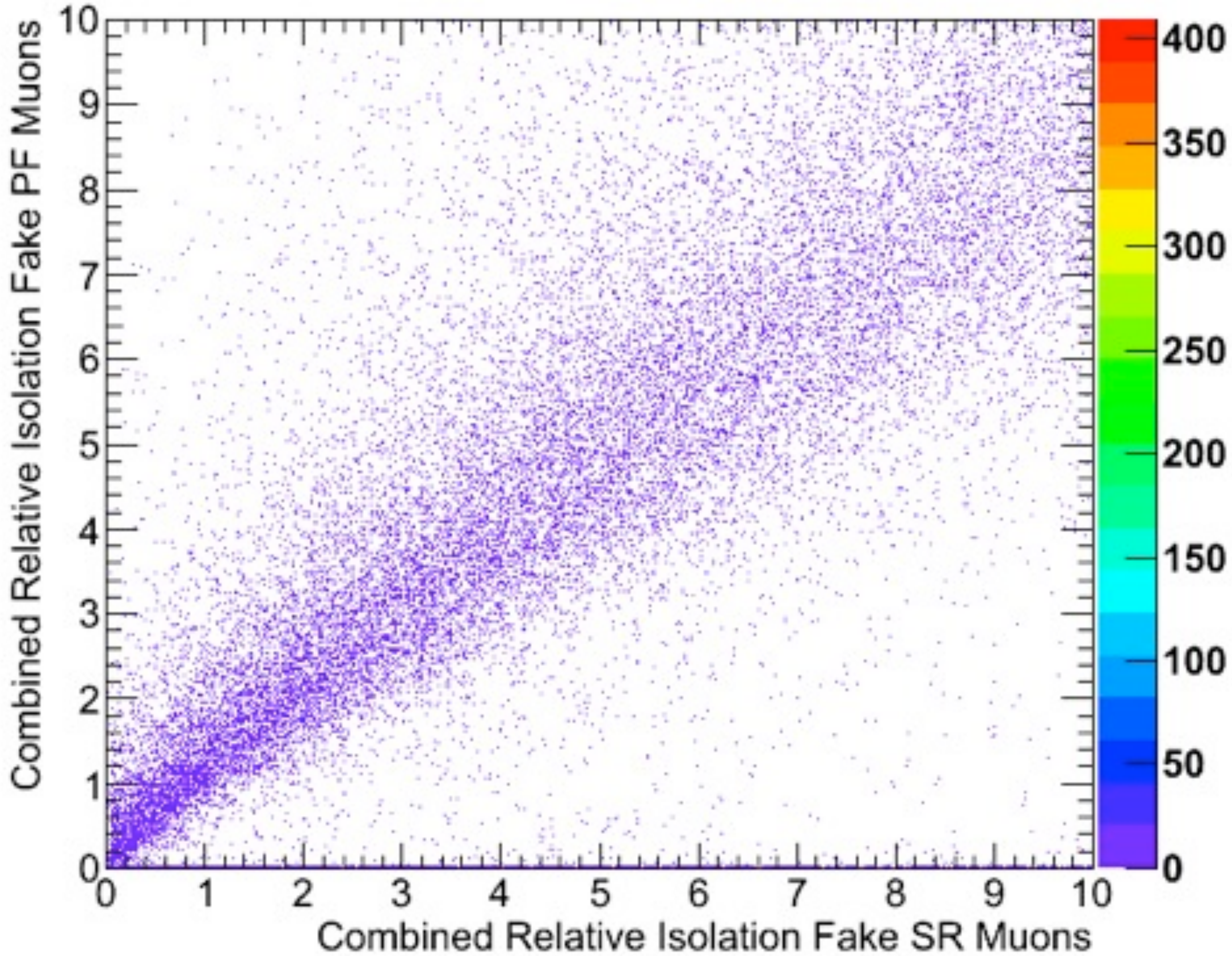
Conclusions

- The methods here described allow us to measure the optimal isolation cut in order to discriminate between prompt, fake and Heavy Flavour leptons.
- We observed an improvement for Particle Flow when comparing with Standard RECO.
- A preliminary plot for efficiency vs rejection was made from data with really few statistics (improve), can be improved.
- HT and the number of jets per event cuts are going to be risen to compare with a SUSY environment.

Backup

Combined Relative isolation fake





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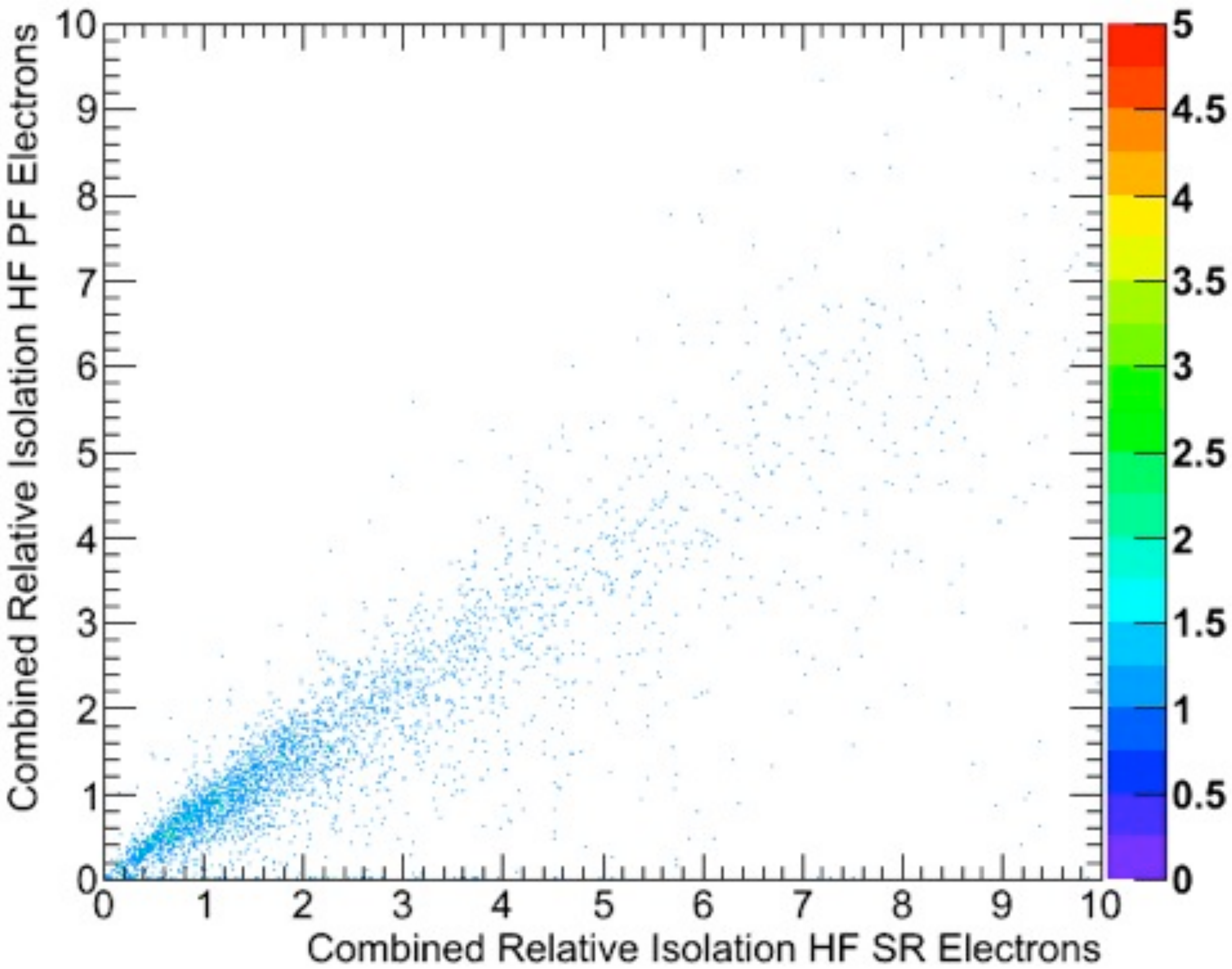
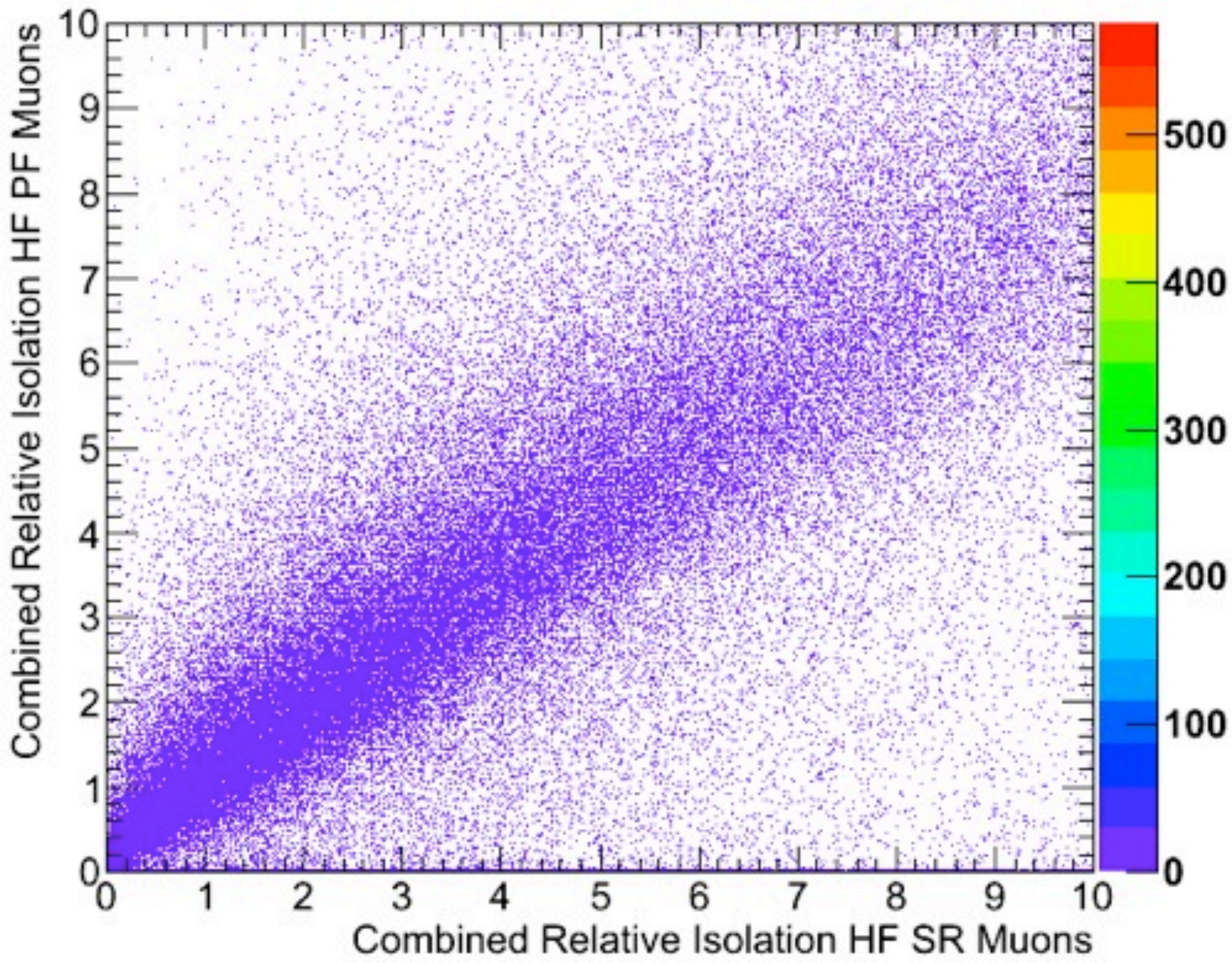
Combined Relative isolation HF





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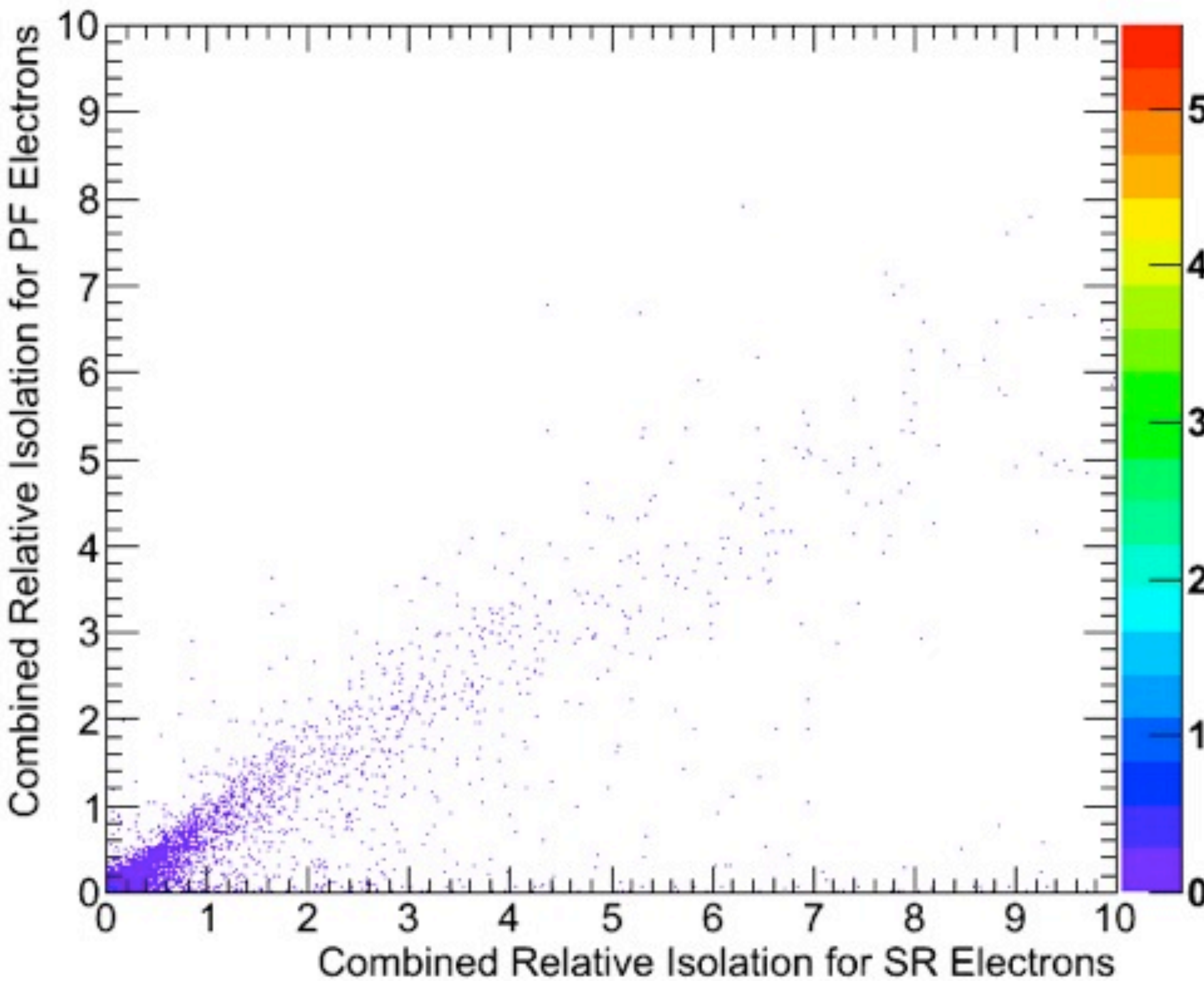
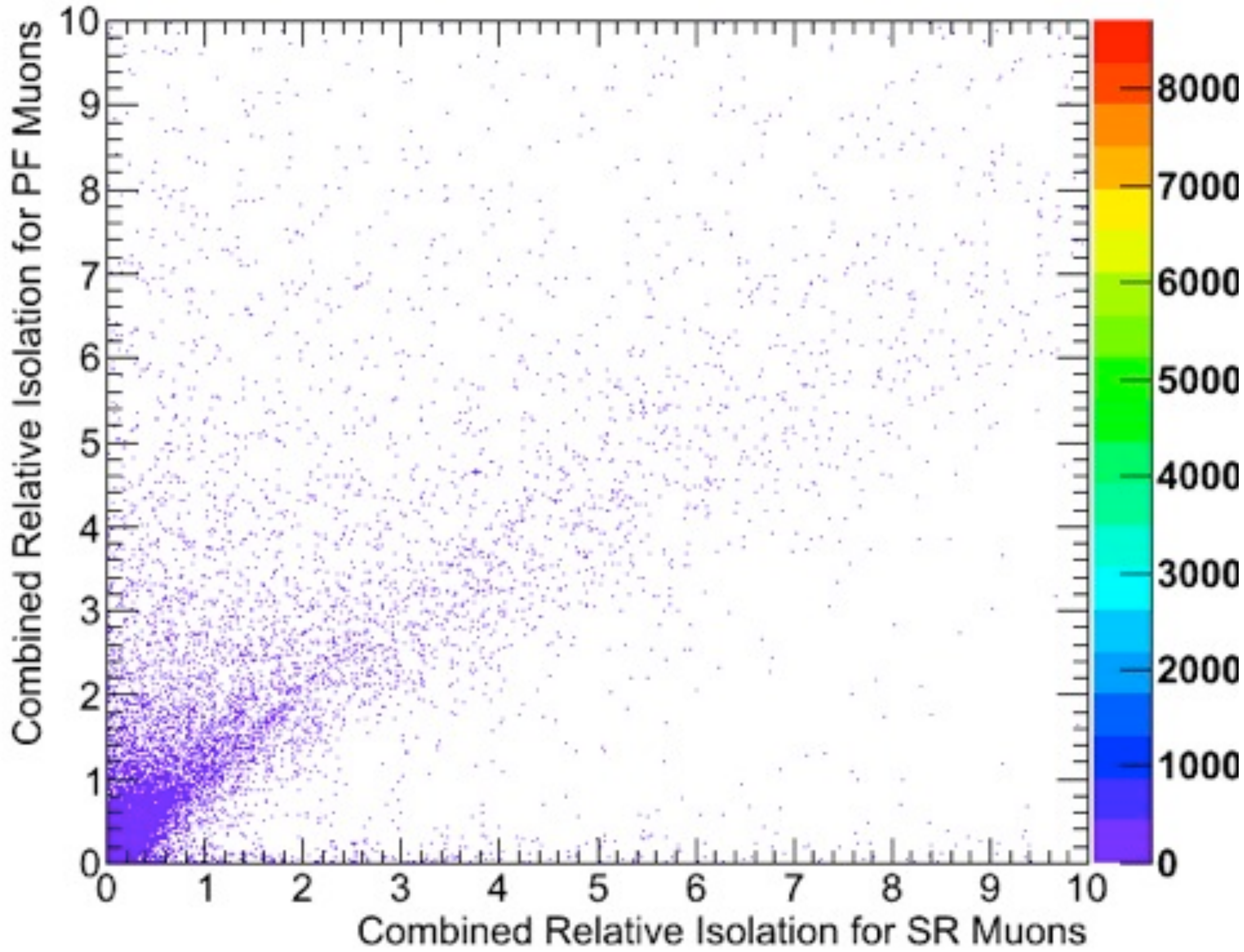
Combined Relative isolation prompt





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Single lepton results

SR Jets and MET

SR Leptons								
Samples	Electrons				Muons			
	$V + j_{p_T>10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}	$V + j_{p_T10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}
LM0	94.67	156.43	192.58	225.03	115.70	142.45	169.42	180.38
LM1	11.78	20.24	27.00	31.69	14.29	17.12	23.03	25.16
QCD 250-500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QCD 500-1000	1.15	7.36	14.72	28.00	0.14	0.87	3.90	8.08
QCD 1000-Inf	2.05	3.26	6.46	12.76	0.02	0.35	1.18	2.36
BB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WJets	182.46	230.70	265.79	280.70	183.33	196.49	226.32	232.46
TT Bar Jets	34.23	46.13	51.64	54.83	34.23	38.59	43.23	44.97
Sig LM0	6.38	9.23	10.47	11.60	7.84	9.27	10.22	10.63
Sig LM1	0.79	1.19	1.47	1.63	0.97	1.11	1.39	1.48
PF Leptons								
LM0	108.83	165.51	202.04	229.87	105.13	139.18	161.95	167.68
LM1	13.49	19.28	25.73	29.28	13.59	17.66	23.51	25.07
QCD 250-500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QCD 500-1000	0.29	4.04	8.95	18.47	0.00	0.87	2.31	3.90
QCD 1000-Inf	0.24	1.34	3.09	6.58	0.02	0.17	0.61	0.97
BB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WJets	185.97	238.60	263.16	272.81	178.07	194.74	221.05	225.44
TT Bar Jets	35.98	48.45	53.09	55.70	33.36	39.75	42.65	42.65
Sig LM0	7.30	9.68	11.15	12.22	7.23	9.07	9.92	10.15
Sig LM1	0.90	1.13	1.42	1.56	0.93	1.15	1.44	1.52

PF Jets and MET

SR Leptons								
Samples	Electrons				Muons			
	$V + j_{p_T>10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}	$V + j_{p_T10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}
LM0	112.39	176.57	210.01	240.18	126.44	152.34	177.14	187.53
LM1	13.77	22.91	29.44	34.02	15.33	18.10	23.60	25.60
QCD 250-500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QCD 500-1000	0.29	3.46	6.35	10.25	0.00	0.00	1.15	1.88
QCD 1000-Inf	1.37	2.05	3.52	7.27	0.02	0.14	0.50	1.11
BB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WJets	356.14	414.91	444.74	452.63	342.11	357.90	385.09	390.35
TT Bar Jets	33.07	44.10	46.71	48.74	36.27	41.20	44.97	46.71
Sig LM0	5.68	8.19	9.38	10.54	6.50	7.62	8.53	8.94
Sig LM1	0.70	1.06	1.31	1.49	0.79	0.91	1.14	1.22
PF Leptons								
Samples	Electrons				Muons			
LM0	126.48	180.09	213.93	239.58	118.22	151.92	173.19	178.03
LM1	15.07	20.88	27.17	30.70	15.06	19.14	24.75	26.24
QCD 250-500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QCD 500-1000	0.14	1.01	2.60	5.77	0.00	0.43	1.01	1.15
QCD 1000-Inf	0.14	0.68	1.53	3.73	0.02	0.07	0.33	0.57
BB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WJets	341.23	391.23	414.91	420.18	339.47	361.40	385.97	389.47
TT Bar Jets	34.52	44.97	47.29	49.03	37.14	42.65	45.26	45.26
Sig LM0	6.52	8.61	9.91	10.95	6.09	7.55	8.33	8.52
Sig LM1	0.78	1.00	1.26	1.40	0.78	0.95	1.19	1.26

Same Single double lepton results

SR Jets and MET

SR Leptons												
Samples	electron-electron				muon-muon				electron-muon			
	$V+j_{p_T>10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}	$V+j_{p_T10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}	$V+j_{p_T10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}
LM0	2.88	7.86	13.41	20.35	3.06	4.95	7.58	10.03	5.30	16.19	26.26	35.15
LM1	0.44	1.21	2.11	3.08	0.54	0.74	1.39	1.63	0.99	2.06	3.76	5.06
QCD 250-500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QCD 500-1000	0.00	0.87	4.33	13.57	0.00	0.00	0.00	1.01	0.00	0.43	2.02	5.92
QCD 1000-Inf	0.00	0.14	0.40	1.32	0.00	0.00	0.02	0.07	0.00	0.00	0.21	0.40
BB	0.00	0.00	0.00	8989.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17979.46
WJets	12.28	50.00	89.47	134.21	0.00	0.88	5.26	8.77	9.65	39.47	99.12	160.53
TT Bar Jets	0.00	2.61	4.06	6.96	0.00	0.58	1.16	2.90	0.00	2.61	5.51	12.77
Sig LM0	0.82	1.07	1.35	0.21	inf	4.10	2.98	2.81	1.71	2.48	2.54	0.26
Sig LM1	0.13	0.17	0.21	0.03	inf	0.61	0.55	0.46	0.32	0.32	0.36	0.04
PF Leptons												
LM0	2.28	6.19	9.78	13.09	3.31	5.66	7.19	7.68	4.02	8.97	13.88	17.58
LM1	0.38	0.82	1.43	1.97	0.59	0.93	1.49	1.65	0.81	1.43	2.50	3.20
QCD 250-500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QCD 500-1000	0.00	0.29	1.44	5.05	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.43
QCD 1000-Inf	0.00	0.02	0.07	0.38	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.07
BB	0.00	0.00	0.00	8989.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WJets	0.88	3.51	6.14	8.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.75
TT Bar Jets	0.00	0.29	0.29	0.87	0.00	0.58	0.58	0.58	0.00	0.29	1.16	2.03
Sig LM0	2.43	3.05	3.47	0.14	inf	7.43	8.31	8.88	inf	16.65	12.88	8.49
Sig LM1	0.41	0.40	0.51	0.02	inf	1.22	1.72	1.90	inf	2.65	2.32	1.54

PF Jets and MET

PF Leptons												
Samples	electron-electron				muon-muon				electron-muon			
	$V+j_{p_T>10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}	$V+j_{p_T10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}	$V+j_{p_T10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}
LM0	2.49	6.69	10.25	13.16	3.74	5.87	7.36	7.97	4.38	9.25	13.95	17.90
LM1	0.39	0.82	1.44	1.97	0.62	0.95	1.51	1.66	0.82	1.46	2.54	3.25
QCD 250-500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QCD 500-1000	0.00	0.14	0.58	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
QCD 1000-Inf	0.00	0.02	0.07	0.26	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.07
BB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WJets	1.75	8.77	10.53	18.42	0.00	0.00	0.00	0.00	0.00	4.39	7.89	12.28
TT Bar Jets	0.00	1.16	1.45	1.74	0.00	0.29	0.29	0.29	0.00	0.29	0.87	1.74
Sig LM0	1.88	2.10	2.88	2.83	inf	10.90	13.15	14.23	inf	4.28	4.71	4.72
Sig LM1	0.29	0.26	0.40	0.42	inf	1.76	2.69	2.97	inf	0.67	0.86	0.86
SR Leptons												
LM0	2.63	7.72	12.95	19.53	3.91	5.16	6.40	7.36	5.05	15.83	25.86	34.62
LM1	0.44	1.22	2.11	3.07	0.70	0.87	1.44	1.60	0.99	2.07	3.77	5.08
QCD 250-500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QCD 500-1000	0.00	0.29	1.15	3.18	0.00	0.00	0.00	0.00	0.00	0.14	0.72	1.88
QCD 1000-Inf	0.00	0.05	0.19	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.28
BB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8989.73
WJets	14.04	67.54	109.65	149.12	0.88	0.88	2.63	4.39	7.89	46.49	90.35	146.49
TT Bar Jets	0.00	3.19	3.77	5.80	0.00	0.00	0.00	0.00	0.00	2.61	5.51	11.60
Sig LM0	0.70	0.92	1.21	1.55	4.18	5.51	3.95	3.52	1.80	2.26	2.63	0.36
Sig LM1	0.12	0.14	0.20	0.24	0.75	0.93	0.89	0.76	0.35	0.29	0.38	0.05

Opposite Single double lepton results

SR Jets and MET

Samples	electron-electron				muon-muon				electron-muon			
	$V+j_{p_T>10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}	$V+j_{p_T10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}	$V+j_{p_T10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}
SR Leptons												
LM0	14.94	29.67	39.56	48.24	19.85	26.08	33.55	36.61	19.46	40.10	57.78	69.38
LM1	3.42	6.15	8.16	9.57	4.44	5.25	6.88	7.33	1.99	3.97	7.17	9.09
QCD 250-500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QCD 500-1000	0.00	1.01	4.91	15.88	0.00	0.00	0.43	1.30	0.00	0.72	2.31	6.64
QCD 1000-Inf	0.05	0.12	0.38	1.49	0.00	0.00	0.02	0.07	0.00	0.02	0.24	0.61
BB	0.00	0.00	8989.73	8989.73	0.00	0.00	0.00	0.00	0.00	0.00	8989.73	17979.46
WJets	6.14	45.61	85.09	137.72	0.00	0.00	6.14	14.91	15.79	60.53	114.04	192.98
TT Bar Jets	8.41	17.41	21.76	25.24	10.44	12.77	13.64	15.67	24.66	38.30	46.42	54.83
Sig LM0	3.91	3.70	0.41	0.50	6.14	7.30	7.46	6.48	3.06	4.02	0.60	0.51
Sig LM1	0.90	0.77	0.09	0.10	1.38	1.47	1.53	1.30	0.31	0.40	0.07	0.07
PF Leptons												
LM0	14.48	24.94	31.20	36.50	11.74	16.97	20.85	21.95	14.44	24.34	33.51	39.14
LM1	3.66	5.18	6.59	7.42	3.28	4.25	5.44	5.70	1.61	2.72	4.81	5.79
QCD 250-500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QCD 500-1000	0.00	0.58	2.74	9.24	0.00	0.00	0.14	0.29	0.00	0.00	0.87	2.16
QCD 1000-Inf	0.00	0.02	0.17	0.64	0.00	0.00	0.02	0.02	0.00	0.00	0.19	0.26
BB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WJets	0.88	3.51	6.14	11.40	0.00	0.00	0.00	1.75	1.75	5.26	7.02	12.28
TT Bar Jets	1.74	3.77	5.22	7.54	2.03	2.61	2.61	2.61	5.51	8.12	10.44	10.73
Sig LM0	8.95	8.88	8.26	6.80	8.24	10.50	12.51	10.15	5.36	6.65	7.79	7.76
Sig LM1	2.26	1.84	1.75	1.38	2.30	2.63	3.26	2.63	0.60	0.74	1.12	1.15

PF Jets and MET

Samples	electron-electron				muon-muon				electron-muon			
	$V+j_{p_T>10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}	$V+j_{p_T10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}	$V+j_{p_T10}$	Eff_{p_T10}	Eff_{p_T5}	Eff_{p_T2}
PF Leptons												
LM0	15.16	25.69	32.38	37.78	12.56	18.22	22.34	23.37	15.87	26.58	35.65	41.23
LM1	3.90	5.47	6.91	7.74	3.53	4.54	5.73	5.99	1.70	2.83	4.97	5.95
QCD 250-500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QCD 500-1000	0.00	0.14	1.01	3.03	0.00	0.00	0.14	0.29	0.00	0.00	0.14	0.87
QCD 1000-Inf	0.00	0.00	0.14	0.35	0.00	0.00	0.02	0.02	0.00	0.00	0.07	0.12
BB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WJets	1.75	7.02	10.53	16.67	0.00	0.00	0.00	1.75	3.51	9.65	13.16	22.81
TT Bar Jets	3.48	6.38	7.54	9.86	3.19	3.48	3.77	3.77	12.19	15.38	16.54	16.83
Sig LM0	6.62	6.98	7.38	6.91	7.03	9.76	11.26	9.67	4.01	5.31	6.52	6.47
Sig LM1	1.70	1.49	1.58	1.42	1.98	2.43	2.89	2.48	0.43	0.57	0.91	0.93
SR Leptons												
LM0	14.20	28.68	38.99	47.64	18.50	22.41	27.89	29.49	19.46	40.06	57.88	69.59
LM1	3.56	6.35	8.37	9.79	4.61	5.16	6.65	6.98	2.02	3.99	7.20	9.10
QCD 250-500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QCD 500-1000	0.00	0.43	1.01	3.18	0.00	0.00	0.14	0.29	0.00	0.29	0.87	2.45
QCD 1000-Inf	0.00	0.07	0.28	0.99	0.00	0.00	0.02	0.02	0.00	0.02	0.14	0.45
BB	0.00	0.00	8989.73	8989.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WJets	7.02	60.53	100.88	155.26	0.00	0.00	1.75	6.14	17.54	62.28	115.79	187.72
TT Bar Jets	7.83	17.70	19.73	22.63	9.57	11.02	11.90	11.90	28.14	40.04	48.45	55.41
Sig LM0	3.68	3.23	0.41	0.50	5.98	6.75	7.50	6.89	2.88	3.95	4.50	4.44
Sig LM1	0.92	0.72	0.09	0.10	1.49	1.56	1.79	1.63	0.30	0.39	0.56	0.58